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the drawing characteristics cannot be adequately controlled under impact forces (refs. 49 and 50).

Lewis Research Center

National Aeronautics and Space Administration  
Cleveland, Ohio, February 24, 1959

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TABLE I. - AEROMEDICAL TERMINOLOGY

[Defining rectilinear acceleration with respect to long axis of the human spine.]

Body in normal seated position (limbs not parallel to long axis of spine), acceleration term	Standing or reclining (limbs parallel to long axis of spine), acceleration term	Direction of acceleration, or direction of stopping force applied to exterior of body	Area of body in compression against restraining device	Terms used in this report
Transverse (chest to back)	Prone	Sternum to spine	Pelvic area (lap and leg straps) Shoulders and rib cage; abdomen (shoulder straps)	Spineward
Transverse (back to chest)	Supine	Spine to sternum	Back of body and back of head (against seat back)	Sternumward
Positive (+G) Headward	Positive (+G)	Hips to head	Buttocks (against seat pan) Feet (against floor) Arms (against arm rests)	Headward
Negative (-G) Footward	Negative (-G)	Head to hips	Pelvic area (lap strap) Shoulders (shoulder straps)	Tailward
Lateral		Shoulder to shoulder (left or right)		Shoulder to shoulder (left or right)



TABLE II. - SCALE OF INJURY\* USED BY CORNELL CRASH INJURY RESEARCH IN CLASSIFYING DEGREE OF BODY INJURY (REF. 51)

	Degree of injury	Classification and description of injury	Degree of injury in this report
		A. Minor or none	
1	No injury		Undebliterated
2	Minor	"Minor" contusions, lacerations, abrasions in any area(s) of the body. Sprains, fractures, dislocations of fingers, toes, or nose. Dazed or slightly stunned. Mild concussion evidenced by mild headache, with no loss of consciousness.	Moderate
		B. Nondangerous	
3	Moderate	"Moderate" contusions, lacerations, abrasions in any area(s) of the body. Sprains of the shoulders or principal articulations of the extremities. Uncomplicated, simple or green-stick fractures of extremities, jaw, or malar structures. Concussion as evidenced by loss of consciousness not exceeding 5 minutes, without evidence of other intracranial injury.	Moderate
4	Severe but not dangerous (survival normally assured)	Extensive lacerations without dangerous hemorrhage. Compound or comminuted fractures, or simple fractures with displacement. Dislocations of the arms, legs, shoulders or pelvis/acetabular processes. Fracture of transverse and/or spinous processes of the spine, without evidence of spinal-cord damage. Simple fractures of vertebral bodies of the dorsal and/or lumbar spines, without evidence of spinal-cord damage. Compression fractures of L-3-4-5. Skull fracture without evidence of concussion or other intracranial injury. Concussion as evidenced by loss of consciousness from 5 to 30 minutes, without evidence of other intracranial injury.	Moderate
		C. Dangerous to life	
5	Serious-dangerous (but survival probable)	Lacerations with dangerous hemorrhage. Simple fractures of vertebral bodies of the cervical spine, without evidence of spinal-cord damage. Compression fractures of vertebral bodies of dorsal spine and/or of L-1 and L-2, without evidence of spinal-cord damage. Crushing of extremities, or multiple fractures. Indication of moderate intrathoracic or intra-abdominal injury. Skull fracture with concussion as evidenced by loss of consciousness from 5 to 30 minutes. Concussion as evidenced by loss of consciousness from 30 minutes to 2 hours, without evidence of other intracranial injury.	Severe
6	Critical-dangerous (survival uncertain or doubtful)	(Includes fatal terminations beyond 24 hours.) Evidence of dangerous intrathoracic or intra-abdominal injury. Fractures or dislocations of vertebral bodies of cervical spine with evidence of cord damage. Compression fractures of vertebral bodies of dorsal spine and/or L-1, L-2, with evidence of spinal-cord damage. Skull fracture, with concussion as evidenced by loss of consciousness from 30 minutes to 2 hours. Concussion as evidenced by loss of consciousness beyond 2 hours. Evidence of critical intracranial injury.	Severe
		D. Fatal degrees of injury	
7	Fatal within 24 hours of accident	Fatal lesions in single region of the body, with or without other injuries to the 4th degree.	Not used
8	Fatal within 24 hours of accident	Fatal lesions in single region of the body, with other injuries to the 5th or 6th degree.	Not used
9	Fatal	Two fatal lesions in two regions of the body, with or without other injuries elsewhere.	Not used
10	Fatal	Three or more fatal injuries - up to demolition of body	Not used

\*Based on observations during first 48 hours after injury and previously normal life expectancy.

TABLE III. - REMARKS OF SUBJECTS USING VARIOUS HARNESS ARRANGEMENTS (SPINEWARD ACCELERATION, REF. 12)

Arrangement of restraining straps (fig. 3)	Harness area, sq in.	Remarks of subjects	Run (ref. 12)
Group D	137.5	(1) Impact to abdomen and shoulders was quite marked. (2) Seat belt was brought up against the upper abdomen, lower rib margins very forcefully, followed by sharp pains to the ribs.	96
Group L	----- 186.0	(1) Hard jolt to the chest and back on impact. (2) The parachute did not press noticeably against the back in comparison with the pressure of the harness straps against the front of the body.	162 163 164 165
Group K	176.5 170.3 176.3 170.3 ----- 198.2 198.7	(1) Impact was well distributed, but pressure was noticeable on shoulders. (2) There was noticeable pressure by inverted "V" leg strap.	142 143 146 147 148 149 150
Group I	204.0 238.0	(1) The deceleration was very well distributed; some discomfort due to pinching the inner aspects of the thighs by the single thickness of #9 nylon in the inverted "V" leg strap.	117 118
Group H	207.5 ----- 207.5 201.3 204.0 217.5 ----- ----- 240.3 238.0 217.5 280.0 217.5 280.0 217.5 280.0 217.5	(1) Subject's weight was distributed rather evenly on all straps. (2) Mild pinching of leg straps in the inner aspects of the thighs.	104 105 108 122 123 124 125 129 130 133 135 210 211 212 213 214 215
Group C	----- 244.5 240.3 217.5 240.3	(1) Over-all shock was well distributed with no actual pain felt in any particular area. (2) Additions of restraint by chest belts resulted in pronounced flexion of the neck and increased subject's discomfort. (3) Less pressure on legs and less pinching of thighs were noted.	95 100 107 110 111

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TABLE IV. - HUMAN-BODY RESTRAINT AND POSSIBLE INCREASED IMPACT SURVIVABILITY

Direction of acceleration imposed on seated occupants	Conventional restraint	Possible survivability increases available by additional body supports	Body-support harness used in experimental live exposures <sup>1</sup>
Spineward: Crew	Lap strap Shoulder straps	Forward facing: (a) Thigh straps (Assume crew members will be performing emergency duties with hands and feet at impact.)	Lap strap Shoulder straps Thigh straps Extremities tied (Chest strap optional)
Passengers	Lap strap	Forward facing: (a) Shoulder straps (b) Thigh straps (c) Nonfailing arm rests (d) Suitable hand-holds (e) Emergency toe straps in floor	(Same as above)
Sternumward: Passengers only	Lap strap	Aft facing: (a) Nondeflecting seat back and (b) Integral, full-height head rest (c) Chest strap (axillary level) (d) Lateral head motion restricted by padded "winged back" (e) Leg and foot barriers (f) Arm rests and hand-holds (prevent arm displacement beyond seat back)	Lap strap Chest strap (axillary level) Integral head rest Crash helmet Hand-holds Foot ties
Headward: Crew	Lap strap Shoulder straps	Forward facing: (a) Thigh straps (b) Chest strap (axillary level) (c) Full, integral head rest (Assume crew members will be performing emergency duties; extremity restraint useless.)	Lap strap Shoulder straps Arm rests (varied) or face curtain
Passengers	Lap strap	Forward facing: (a) Shoulder straps (b) Thigh straps (c) Chest strap (axillary level) (d) Full, integral head rest (e) Nonfailing contoured arm rests (f) Suitable hand-holds  Aft facing: (a) Chest strap (axillary level) (b) Full, integral head rest (c) Nonfailing arm rests (d) Suitable hand-holds	(Same as above)
Tailward: Crew	Lap strap Shoulder straps	Forward facing: (a) Lap-belt tie-down strap (Assume crew members will be performing emergency duties; extremity restraint useless.)	Lap strap Shoulder straps Lap-belt tie-down strap Hand-holds Leg and ankle restraint
Passengers	Lap strap	Forward facing: (a) Shoulder straps (b) Lap-belt tie-down strap (c) Hand-holds (d) Emergency toe straps  Aft facing: (a) Chest strap (axillary level) (b) Hand-holds (c) Emergency toe straps	(Same as above)
Berthed occupants	Lap strap	Feet forward: Full-support webbing net  Athwart ships: Full-support webbing net	No human experiments

<sup>1</sup>Exceptionally strong seats employed for live experiments. Maximum exposure in live experiments generally required straps exceeding conventional strap strength and width.

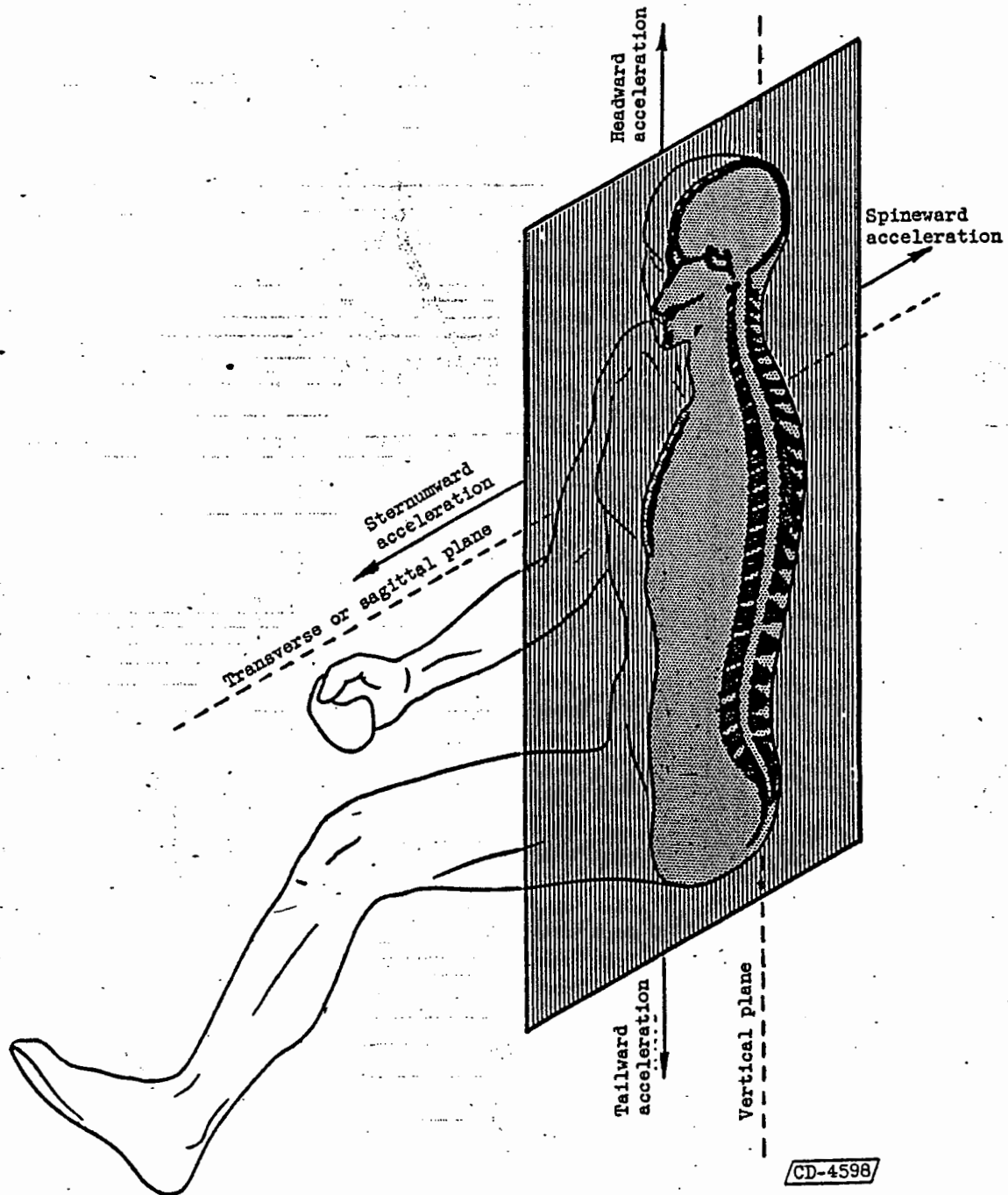


Figure 1. - Sectional view establishing typical nomenclature for acceleration components applied to the seated human body.



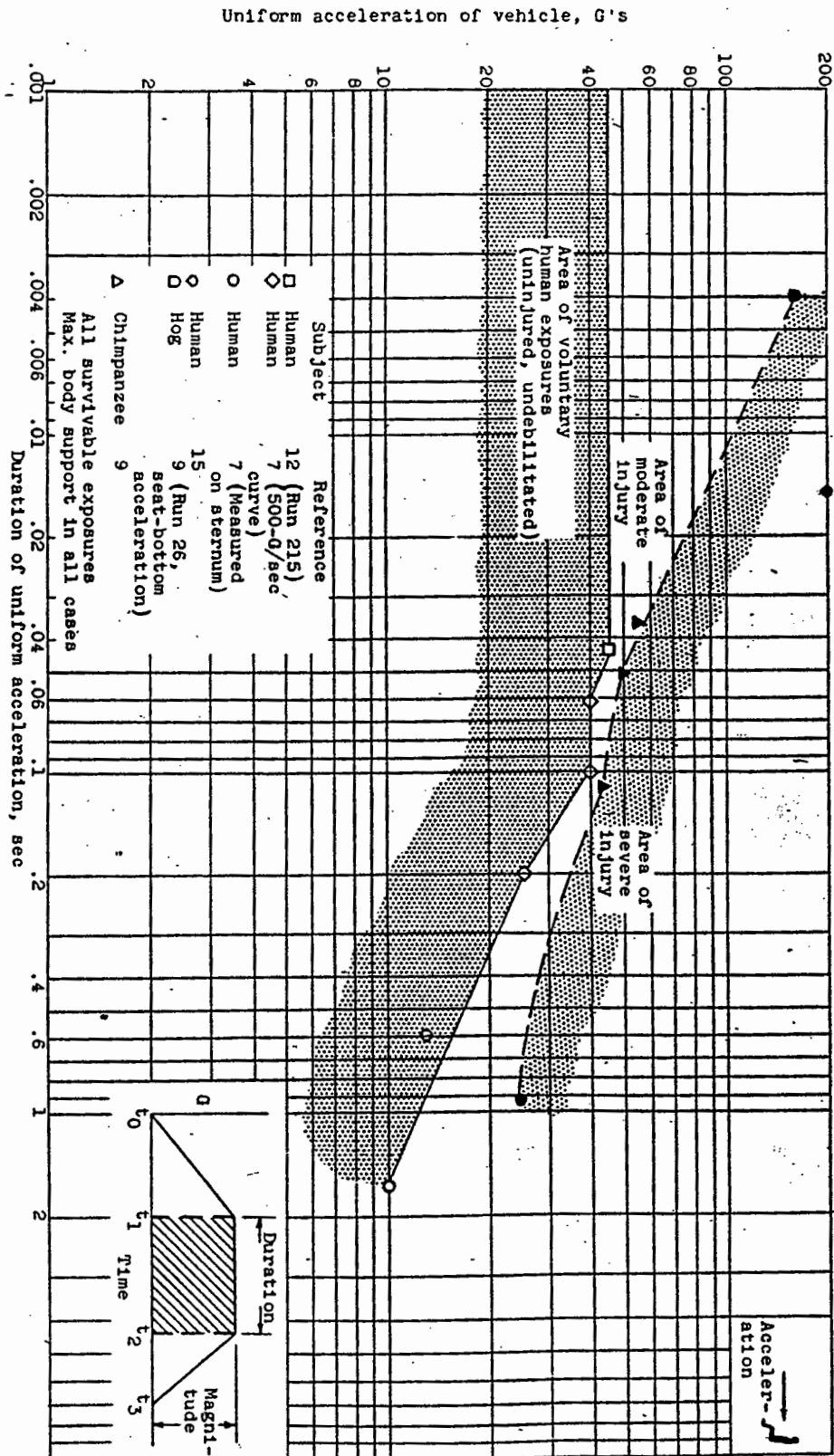
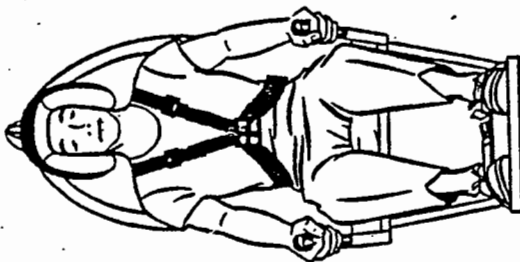
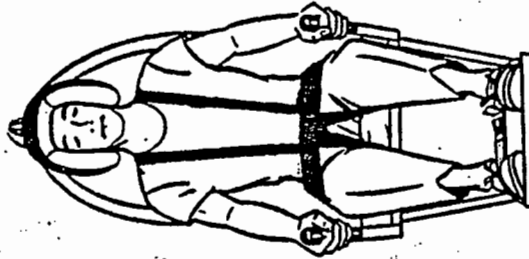


Figure 2. - Duration and magnitude of spinward acceleration endured by various subjects.

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- (a) Seat belt, #9 nylon, 3" wide  
 (b) Shoulder strap, M-16 #8 nylon  
 1 3/4" wide (Group D)



- (a) Seat belt, #9 nylon, 3" wide  
 (b) Shoulder strap, #10 nylon,  
 1 3/4" wide  
 (c) Leg strap, #9 nylon, 3" wide  
 (inverted "v") (Group K)

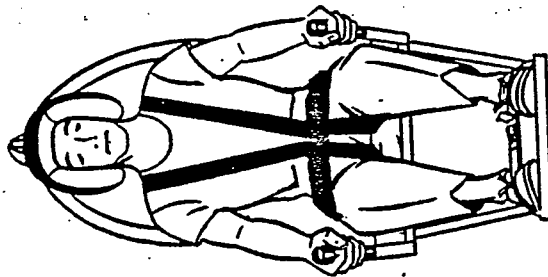
- (a) Seat belt, #9 nylon, 3" wide  
 (b) Shoulder straps, #10 nylon,  
 1 3/4" wide, two straps  
 (c) Leg strap, #9 nylon, 3" wide  
 (inverted "v")  
 (d) B-8 Parachute back-pack type  
 (Group L)

Note: Hand grips insufficient;  
 wrist and foot ties used  
 in all except preliminary  
 runs. Slack emergency  
 chest belt used in all runs.

Acceleration →

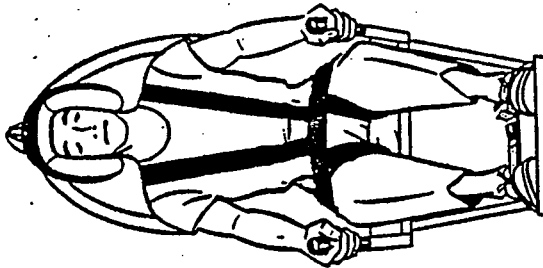
Figure 3. - Significant harness arrangements studied in reference 12.

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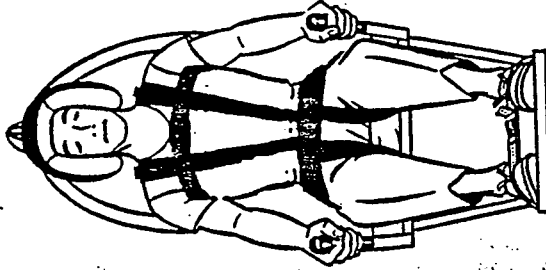


- (a) Seat belt, #9 nylon, 3" wide
  - (b) Shoulder strap, #9 nylon, 3" wide
  - (c) Leg strap, #9 nylon, 3" wide (inverted "v")
- (Group I)

Note: Hand grips insufficient; wrist and foot ties used in all except preliminary runs. Slack emergency chest belt used in all runs.



- (a) Seat belt, #9 nylon, 3" wide
  - (b) Shoulder strap, #9 nylon, 3" wide
  - (c) Leg strap, #9 nylon, 3" wide, two straps
- (Group H)



- (a) Seat belt, #9 nylon, 3" wide
  - (b) Shoulder strap, #9 nylon, 3" wide, two straps
  - (c) Leg strap, #9 nylon, 3" wide, two straps
  - (d) Chest belt, #9 nylon, 3" wide
- (Group C)

Acceleration →

Figure 3. - Concluded. Significant harness arrangements studied in reference 12.



NOT REPRODUCIBLE

E-345



Figure 4. - Body restraint required for maximum spineward human exposures on linear decelerator. Thigh straps are obscured in this view (ref. 15).



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Acceleration →

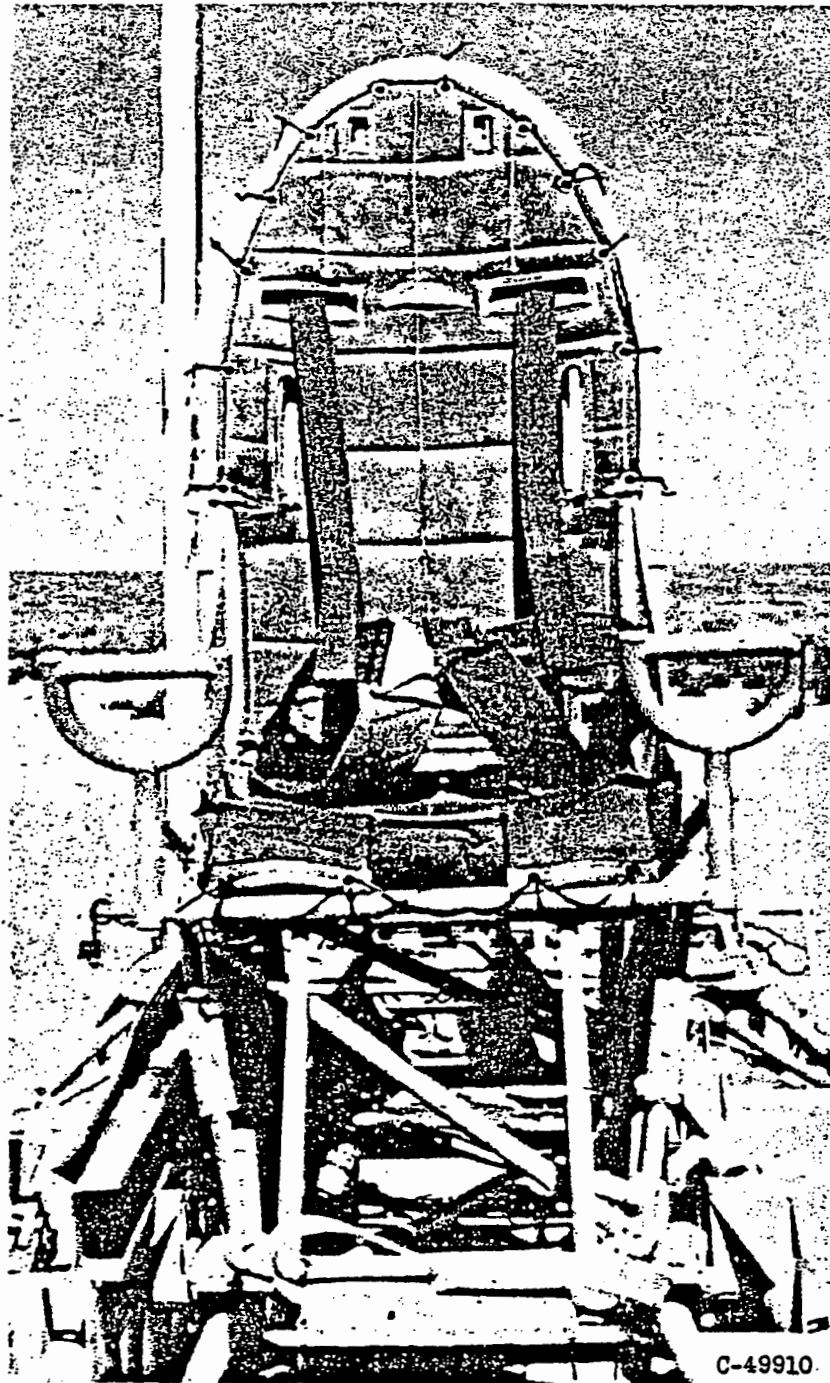


Figure 5. - Inverted "V" thigh-strap arrangement with lap and shoulder straps used in spineward human experiments.